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Masuta et al.

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(54) **POLISHING APPARATUS**

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(52) **U.S. Cl.** **451/286**; 451/285; 451/288; 451/397
(58) **Field of Search** 451/41, 285–289

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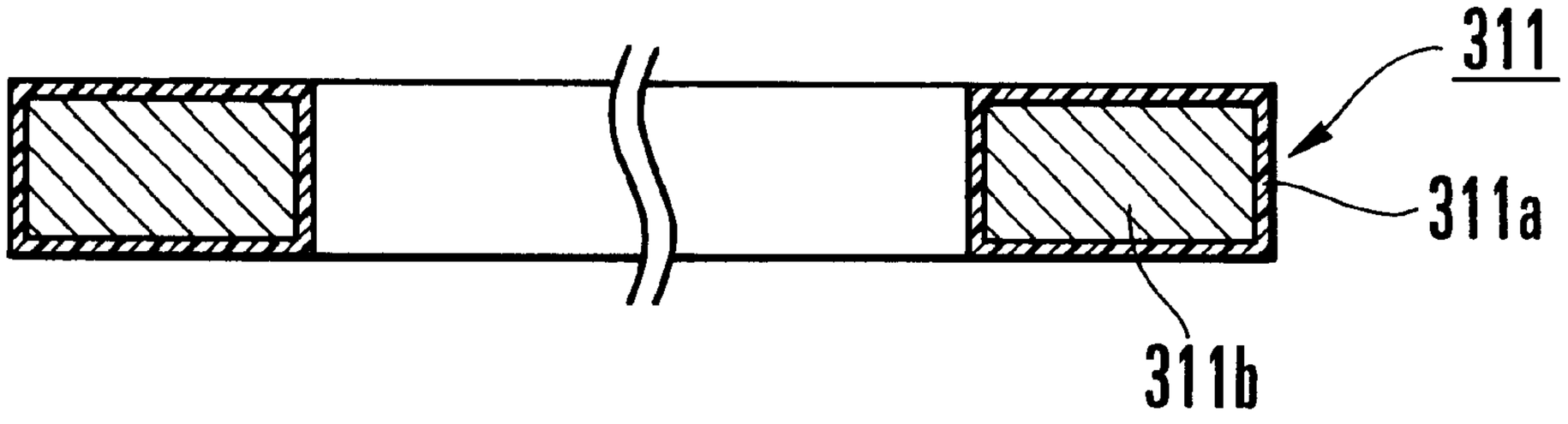
(57) **ABSTRACT**

A polishing apparatus includes a polishing pad, a substrate holder, and a retainer ring. The polishing pad is adhered to a polishing table. The substrate holder urges, while it holds a substrate as a polishing target, a polishing target surface of the substrate against the polishing pad. The retainer ring is formed on a holding surface of the substrate holder to correspond to the circumference of the substrate. The retainer ring has a resin portion formed on its surface which is to come into contact with the polishing pad, and an annular resin holding portion for holding the resin portion and made of a material having a higher mechanical strength than the resin portion.

2 Claims, 4 Drawing Sheets



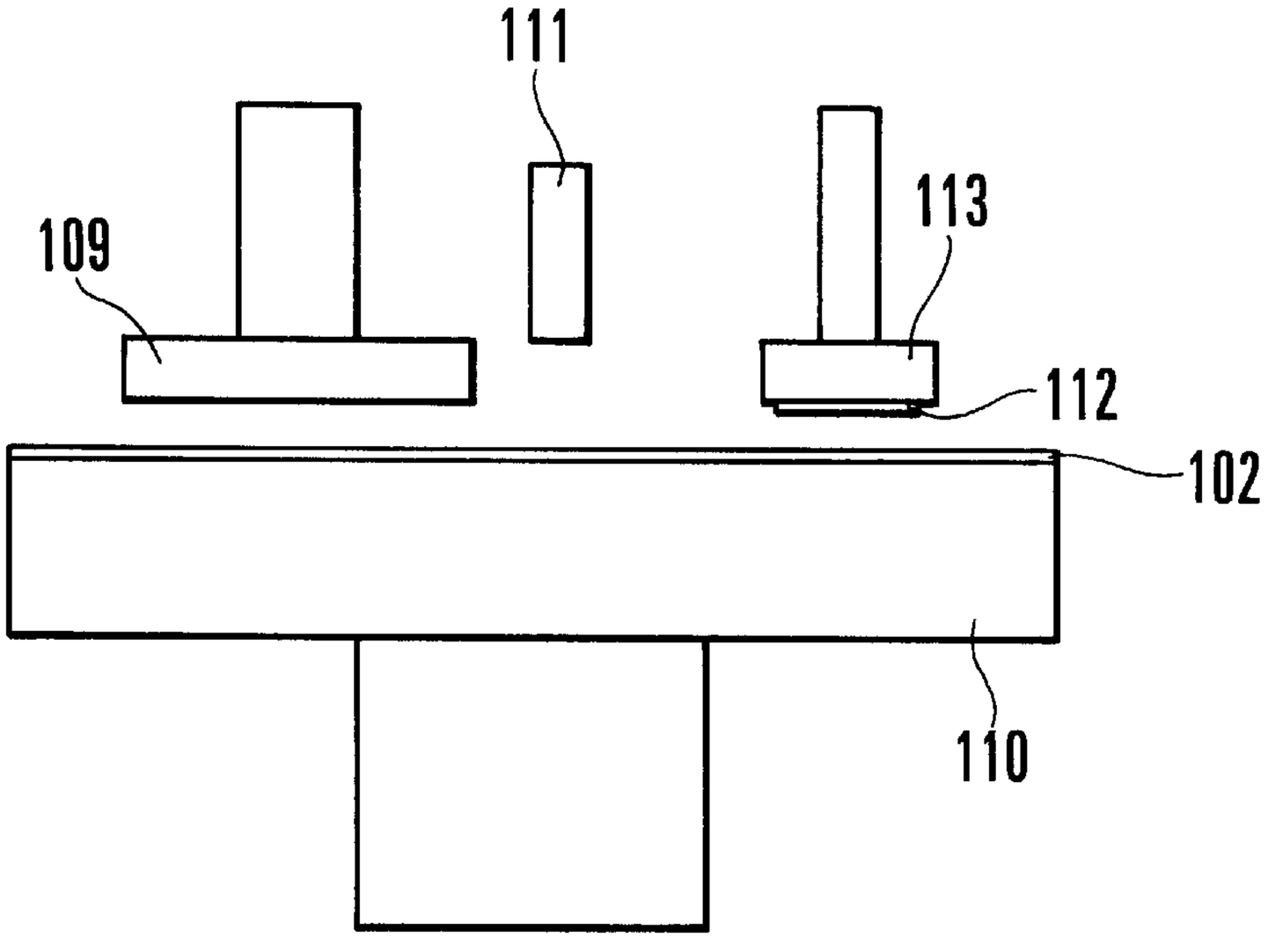

111
109
113
112
102
110

FIG. 1A

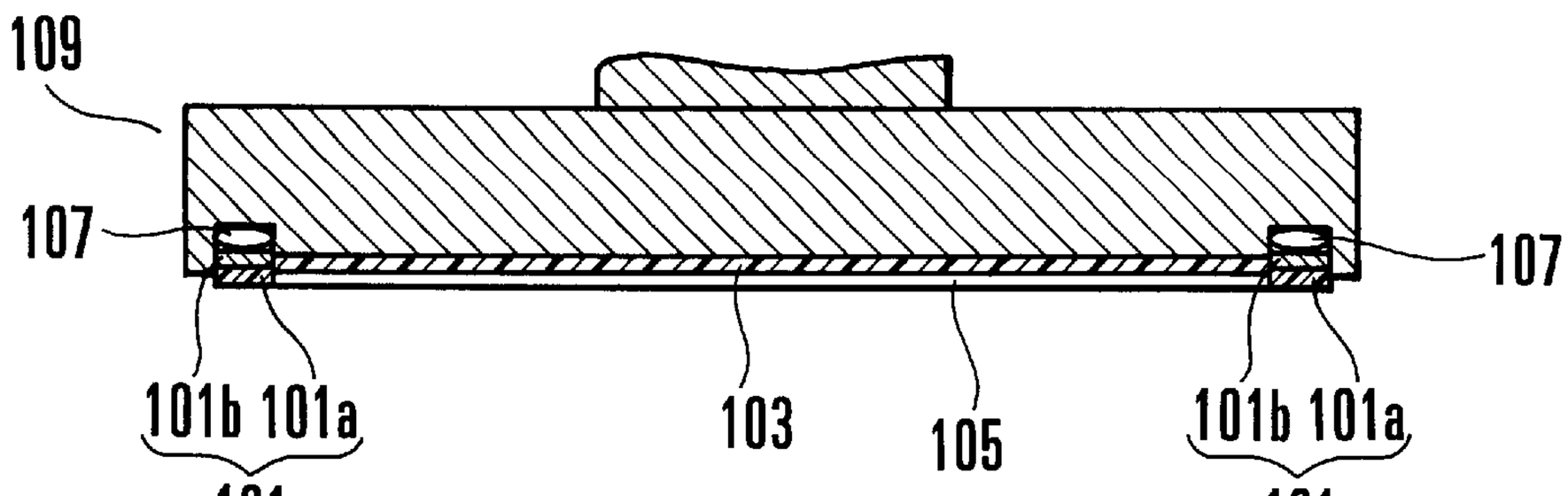

109
107
107
101b 101a
103
105
101b 101a
101
101

FIG. 1B

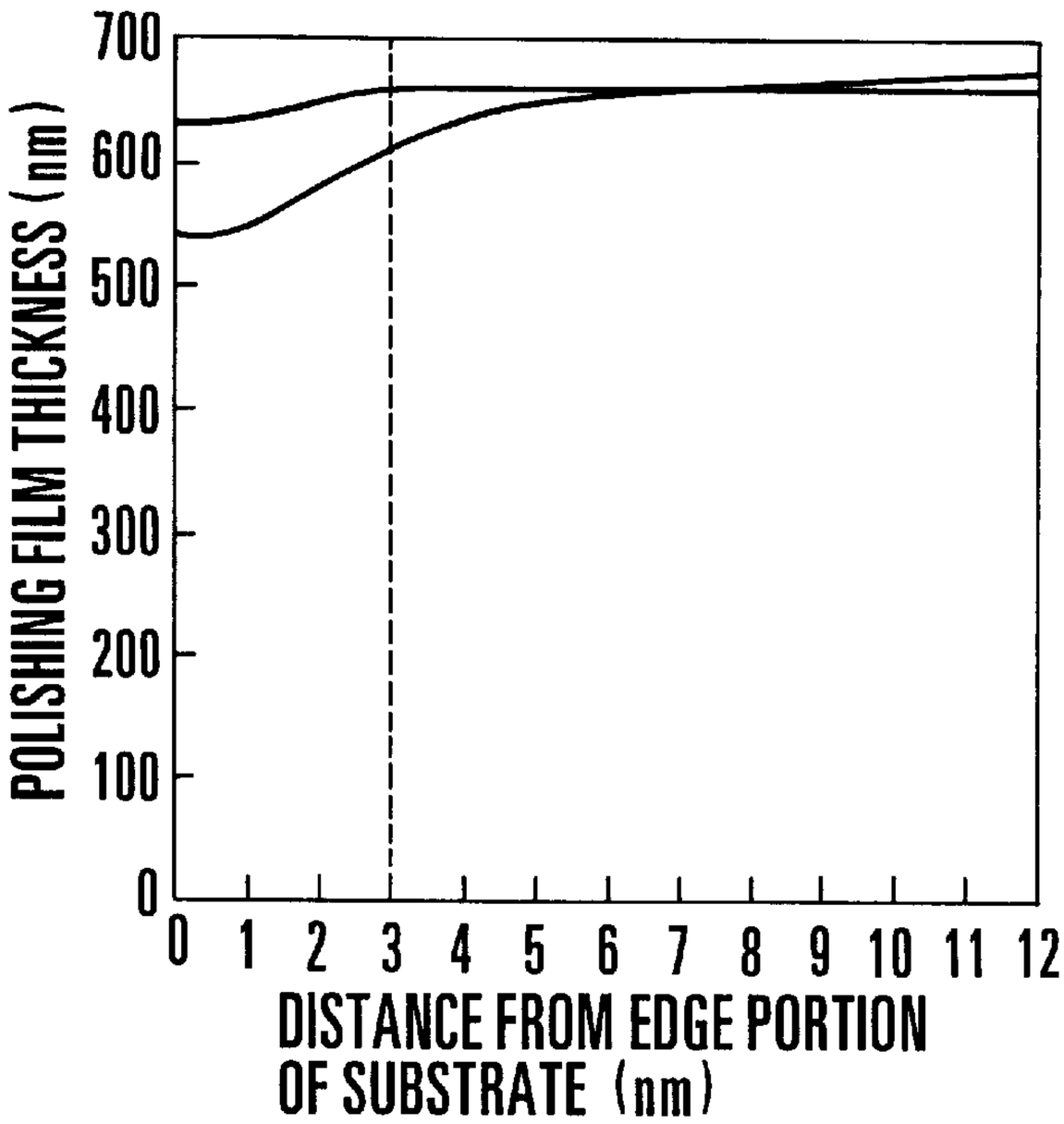


FIG. 2

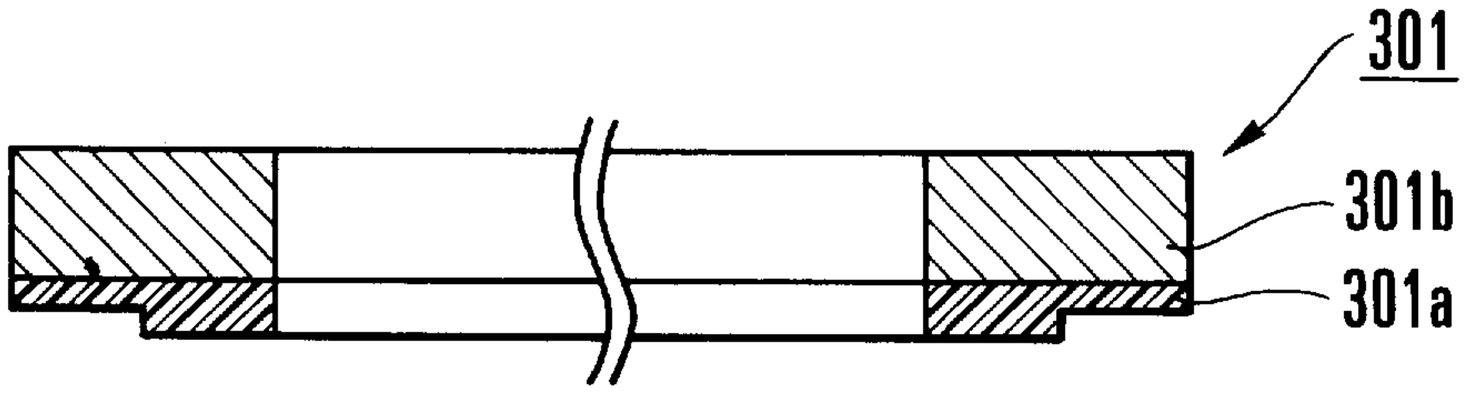


FIG. 3A

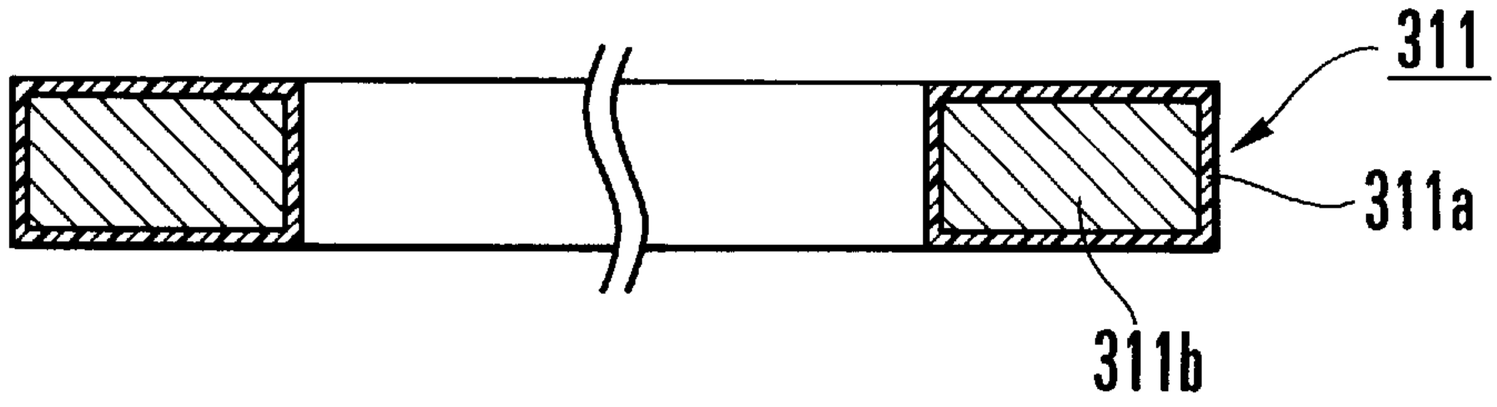


FIG. 3B

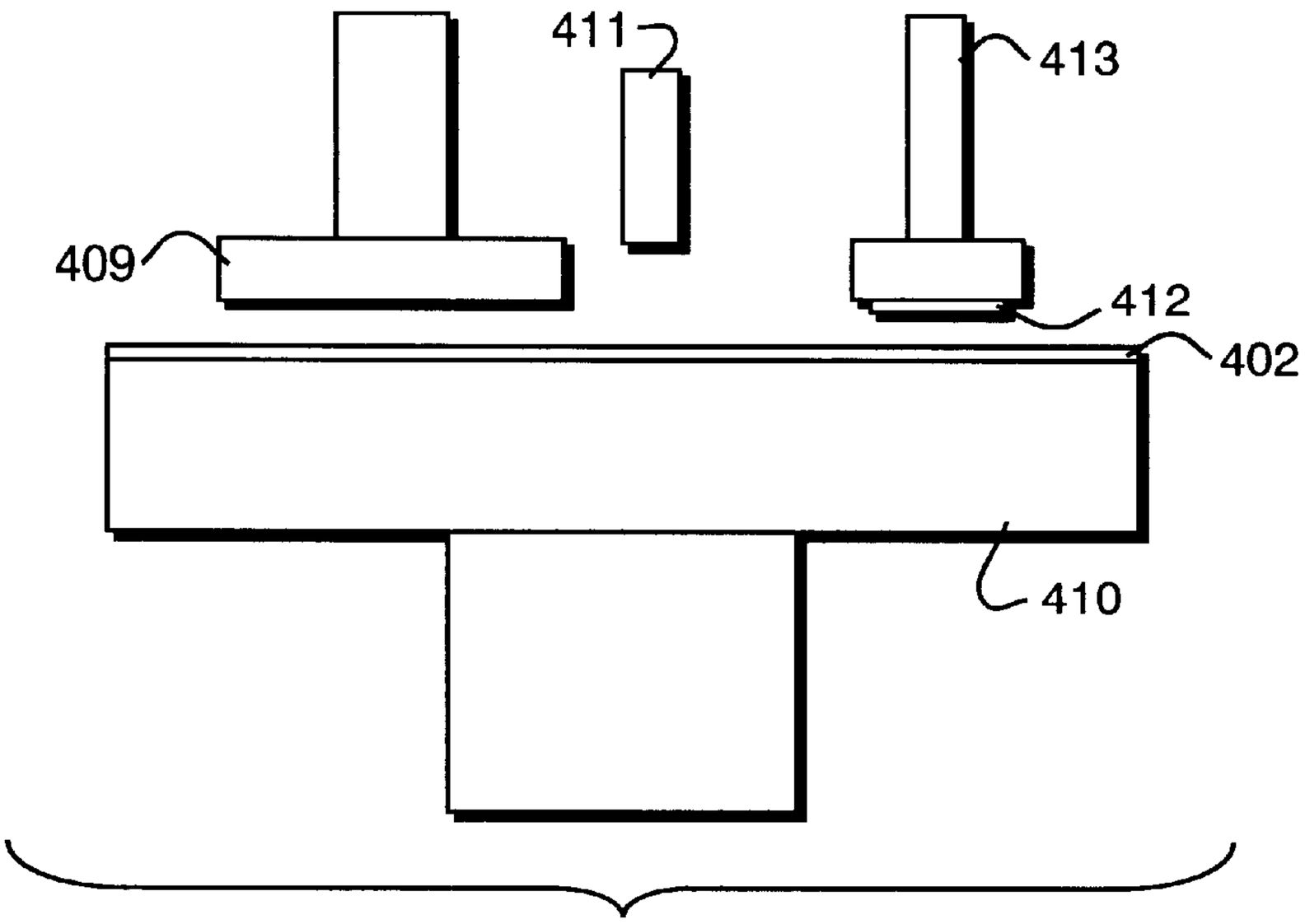


FIG. 4A
(PRIOR ART)

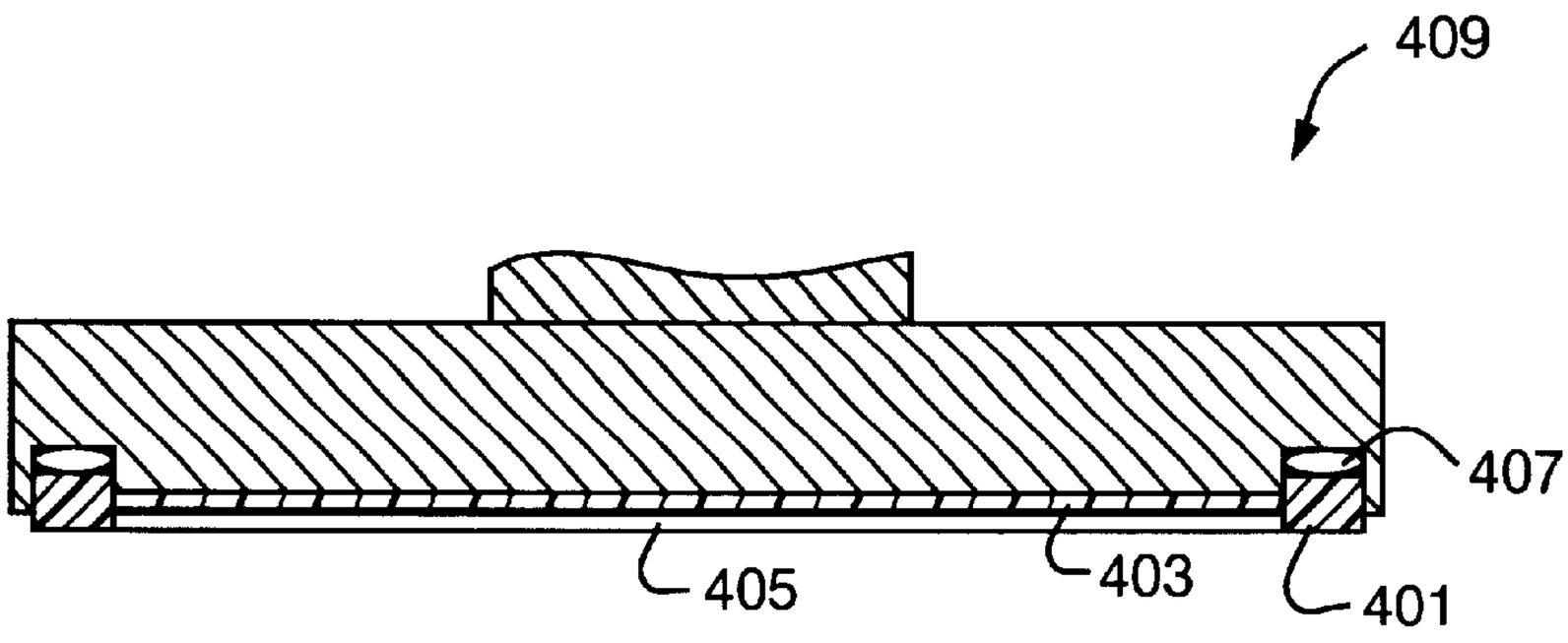


FIG. 4B
(PRIOR ART)

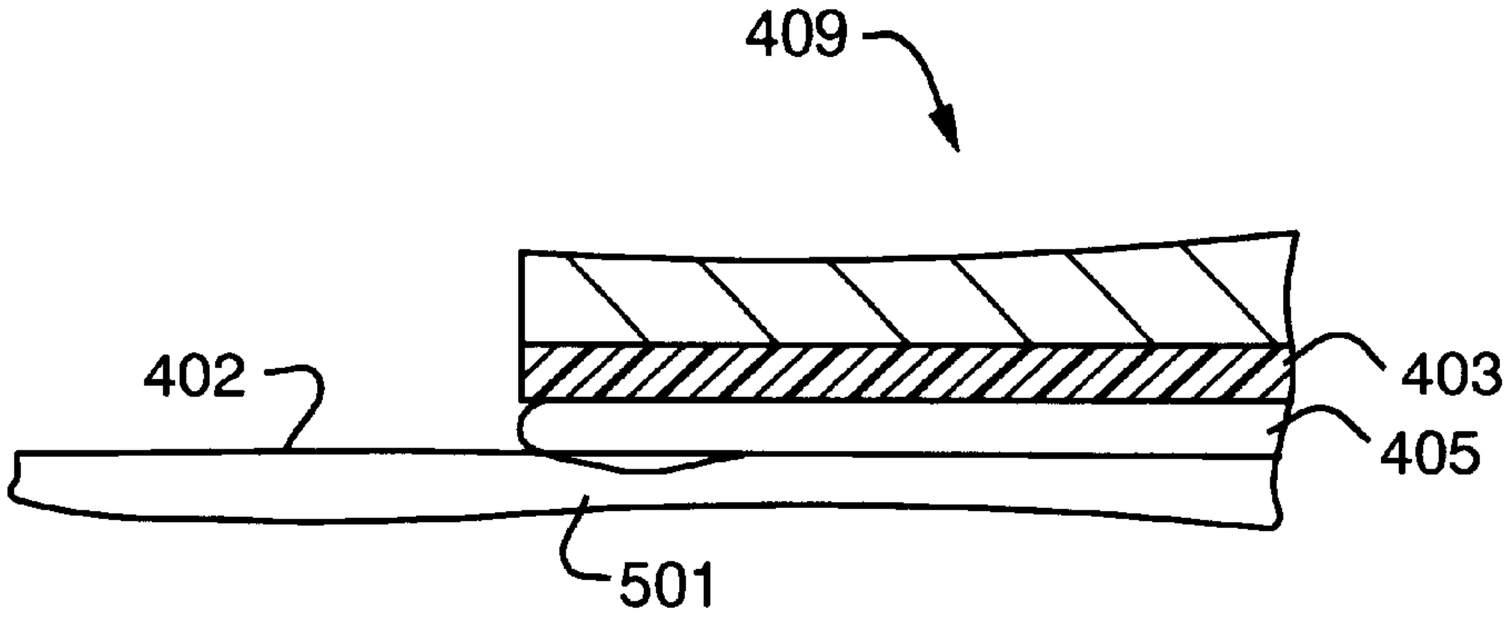


FIG. 5A
(PRIOR ART)

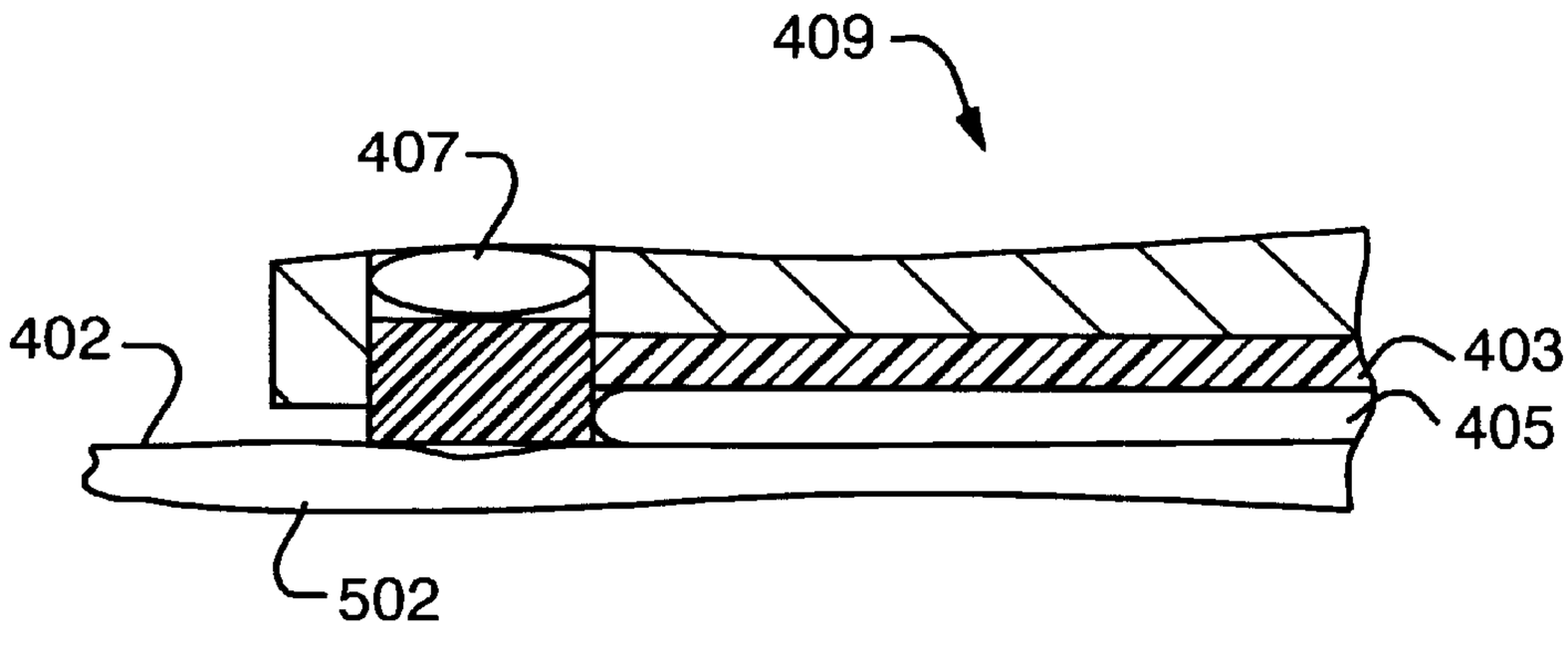


FIG. 5B
(PRIOR ART)

POLISHING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a polishing apparatus used in, e.g., chemical-mechanical polishing (CMP).

A technique for planarizing a substrate surface by polishing has been employed in many fields including the semiconductor substrate fabrication process. In recent years, CMP for planarizing the unevenness of a surface, e.g., the unevenness of the surface of an interlevel insulating film, formed during the fabrication by polishing is used in a process of fabricating devices on a semiconductor substrate.

In CMP, hard polishing cloth made of a material such as foamed polyurethane, different from relatively soft polishing cloth comprised of unwoven fabric used for polishing the surface of the semiconductor substrate, is used to planarize the insulating film. To obtain the polishing uniformity within the substrate surface, an elastic cushion layer is generally formed under a hard pad.

FIGS. **4**A and **4**B show the arrangement of a conventional polishing apparatus.

As shown in FIG. **4**A, the conventional polishing apparatus is constituted by a substrate holder **409** for holding a polishing target, a polishing table **410** to which a polishing pad **402** is adhered, an abrasive supply member **411**, and a conditioning mechanism **413** on which a diamond pellet **412** is mounted. Mechanisms provided to the substrate holder **409** and conditioning mechanism **413** to rotate, swing, and press them, and a rotational mechanism provided to the polishing table **410** are not illustrated.

As shown in FIG. **4**B, a retainer ring **401** is set on a surface of the substrate holder **409** which opposes a substrate **405**, to correspond to the circumference of the substrate **405**. The retainer ring **401** holds the substrate **405** and prevents lateral shift of the substrate **405**. As the material of the retainer ring **401**, a hard plastic such as polyethylene terephthalate is used. An air cushion **407** applies a downward load to the retainer ring **401**. An elastic layer called an insert pad **403** is formed on the surface of the substrate holder **409** inside the retainer ring **401**.

By using the polishing arrangement having the above arrangement, for example, the surface of an interlevel insulating layer in the multilevel interconnection structure of an LSI is planarized.

During polishing, the retainer ring **401** prevents not only lateral shift of the substrate **405** but also abnormal polishing of the outer peripheral portion of the substrate **405**. More specifically, during polishing, the substrate **405** is urged against the polishing table **410** by the polishing pad **402** consisting of an upper hard layer and a lower soft layer. The contact pressure is the maximum at the outer peripheral portion of the substrate **405**.

At this time, as shown in FIG. **5**A, the polishing pad **402** is deformed by the pressing force of the substrate **405** for several mm from the outer peripheral portion of the substrate **405**, and the pressure acting on the outer peripheral portion of the substrate **405** decreases. As a result, the polishing amount on the outer peripheral portion of the substrate **405** decreases. In particular, depending on the modulus of elasticity of the insert pad **403** and other polishing conditions, a deformation region **501** of the polishing pad **402** sometimes extends for several cm from the outer peripheral portion of the substrate **405**.

In the conventional polishing apparatus, abnormal polishing is suppressed in the following manner. First, the

surfaces of the retainer ring **401** and substrate **405** that are to come into contact with the polishing pad **402** are set to be flush. The width of the retainer ring **401** with which the retainer ring **401** is to come into contact with the polishing pad **402** is set to be equal to or more than the deformation region described above of the polishing pad **402**. This suppresses a deformation region **502** from extending over the outer peripheral portion of the substrate **405**, as shown in FIG. **5**B.

A load is applied to the retainer ring **401** by the air cushion **407** independently of applying a load to the substrate **405**. This makes the pressure that presses the retainer ring **401** against the polishing pad **402** independent and constant. For example, the retainer ring **401** is brought into contact with the polishing pad **402** with a load of about 500 g/cm^2 (≈7 psi).

For this reason, during polishing, the retainer ring **401** is also polished by the polishing pad **402**, and the material of the retainer ring **401** generated by grinding spreads over the polishing pad **402** as impurities. In this case, if an alloy material such as stainless steel is used to form the retainer ring **401**, the metal component generated by grinding spreads over the polishing pad **402** to adversely affect the characteristics of devices formed on the substrate **405**. Also, the cutting chips of the alloy material damage the polishing surface of the polishing pad **402**. To solve these problems, a plastic is used as the material of the conventional retainer ring **401**.

As the process amount increases, the plastic retainer ring **401** deforms, and the specified performance is not maintained.

In this case, even if a hard plastic is used to suppress deformation, its mechanical strength is limited and inferior to that of a metal alloy material such as stainless steel. Even a conventional retainer ring using a hard plastic deforms when the number of polishing processes increases, and the capability of the retainer to press the polishing pad degrades. As a result, in the conventional polishing apparatus, when the number of polishing processes increases, an abnormality in polishing amount occurs on the outer peripheral portion of the substrate as a polishing target.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a polishing apparatus in which, even if the number of polishing processes increases, occurrence of an abnormality in polishing amount on the outer peripheral portion of the substrate as a polishing target is suppressed.

In order to achieve the above object, according to the present invention, there is provided a polishing apparatus comprising a polishing pad adhered to a polishing table, a substrate holder for urging, while holding a substrate as a polishing target, a polishing target surface of the substrate against the polishing pad, and a retainer ring formed on a holding surface of the substrate holder to correspond to a circumference of the substrate, the retainer ring having a resin portion formed on a surface thereof which is to come into contact with the polishing pad, and an annular resin holding portion for holding the resin portion and made of a material having a higher mechanical strength than the resin portion.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a front view of a polishing apparatus according to an embodiment of the present invention, and FIG. **1**B is

a sectional view of the main part of the substrate holder shown in FIG. **1**A;

FIG. **2** is a graph showing the polishing characteristics;

FIGS. **3**A and **3**B are views each showing deformation of the retainer ring shown in FIG. **1**B;

FIG. **4**A is a front view of a conventional polishing apparatus, and

FIG. **4**B is a sectional view of the main part of the substrate holder shown in FIG. **4**A; and

FIGS. **5**A and **5**B are views each showing deformation of the polishing pad.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will be described in detail with reference to the accompanying drawings.

FIG. **1** schematically shows a polishing apparatus according to an embodiment of the present invention. As shown in FIG. **1**A, the polishing apparatus according to this embodiment is constituted by a substrate holder **109** for holding a substrate as a polishing target, a polishing table **110** to which a polishing pad **102** is adhered, an abrasive supply member **111**, and a conditioning mechanism **113** on which a diamond pellet **112** is mounted.

The polishing pad **102** has a two-layered structure constituted by an upper hard layer and a lower soft layer. Mechanisms provided to the substrate holder **109** and conditioning mechanism **113** to rotate, swing, and press them, and a rotational mechanism provided to the polishing table **110** are not illustrated.

As shown in FIG. **1**B, a retainer ring **101** is set on a surface (holding surface) of the substrate holder **109** which opposes a substrate **105**, to correspond to the circumference of the substrate **105**. The retainer ring **101** holds the substrate **105** and prevents lateral shift of the substrate **105**. An air cushion **107** biases the retainer ring **101** toward the polishing table **110**. An elastic layer called an insert pad **103** is formed on the surface of the substrate holder **109** inside the retainer ring **101**.

To perform polishing, the polishing target surface of the substrate **105** is pressed against the polishing pad **102** through the insert pad **103**. For example, part of the multilevel interconnection structure of an LSI is formed on the polishing target surface of the substrate **105**, and an interlevel insulating film is formed on the uppermost layer of the multilevel interconnection structure. An unevenness formed by a lower wiring layer or the like is present on the surface of the interlevel insulating film. The polishing apparatus of this embodiment planarizes this unevenness by cutting and polishing in accordance with CMP.

As shown in FIG. **1**B, the retainer ring **101** is constituted by a lower resin portion **101***a* made of a hard plastic such as polyethylene terephthalate, and an upper metal portion **101***b* made of, e.g., SUS **316** (stainless steel). The metal portion **101***b* serving as a resin holding portion, and the resin portion **101***a* are firmly bonded to each other with an adhesive. A surface of the resin portion **101***a* of the retainer ring **101** which is to come into contact with the polishing pad **102** is set to be flush with that of the polishing target surface of the substrate **105**.

The retainer ring **101** is biased by using the air cushion **107** independently of controlling a load to the substrate **105**. This makes the pressure that presses the retainer ring **101** against the polishing pad **102** independent and constant. For example, the retainer ring **101** is brought into contact with the polishing pad **102** with a biasing force (pressure) of about 500 g/cm^2 (≈7 psi).

According to this embodiment, the retainer ring **101** has a two-layered structure constituted by the resin portion **101***a* and metal portion **101***b*. As a result, compared to a conventional case wherein the whole retainer ring is formed of a hard plastic, the mechanical strength of the retainer ring **101** increases considerably.

Of the retainer ring **101**, only its resin portion **101***a* comes into contact with the polishing pad **102**, and its metal portion **101***b* does not. Therefore, no metal component will spread over the polishing pad **102** to adversely affect the characteristics of devices formed on the substrate **105**. Also, the polishing surface of the polishing table will not be damaged by the cutting chips of the metal material.

A practical example of polishing apparatus of this embodiment will be described.

In the polishing apparatus using the retainer ring **101**, an 8-inch diameter silicon substrate formed with an oxide film on its surface was employed as a sample. The oxide film was removed by CMP. The thickness of the oxide film to be removed by polishing was set to about 650 nm. Under these conditions, 25 substrates were polished. When the 26th substrate was polished, a region where the polishing film thickness was smaller by about 20 nm to 30 nm was formed at a region of about 3 mm from the outer peripheral portion of the silicon substrate, as indicated by a curve (a) of FIG. **2**.

In contrast to this, the same process was performed by using the conventional retainer ring **401** (FIG. **4**B) formed of only a hard plastic. As a result, a region where the polishing film thickness was small was formed at a region of about 5 mm or more from the outer peripheral portion of the silicon substrate, as indicated by a curve (b) of FIG. **2**.

In this manner, when the retainer ring **101** of this embodiment is used, even if the polishing process amount increases, abnormal polishing occurring on the outer peripheral portion of the substrate as the polishing target can be suppressed.

In the embodiment, the resin portion **101***a* and metal portion **101***b* of the retainer ring **101** have almost the same shape. However, the present invention is not limited to this. For example, as shown in FIG. **3**A, a stepped resin portion **301***a* may be formed, and the shapes of the resin portion **301***a* and a metal portion **301***b* may be different from each other. When a retainer ring **301** is formed in this manner, its mechanical strength and its contact area with the polishing pad **102** of the polishing table **110** can be designed freely.

As shown in FIG. **3**B, a retainer ring **311** may be formed such that its resin portion **311***a* covers its annular metal portion **311***b*. When the retainer ring **311** is formed in this manner, the resin portion **311***a* and metal portion **311***b* need not be brought into tight contact with each other through an adhesive or the like. As a result, even when the resin portion **311***a* cannot be adhered to the metal portion **311***b* depending on combinations of the materials, the retainer ring **311** can be fabricated.

In the above embodiment, stainless steel is used to form the metal portion, and polyethylene terephthalate is used to form the resin portion. However, the present invention is not limited to this, but the following engineering plastics may be used instead. More specifically, examples are polycarbonate, polyamide, polybutylene terephthalate, polysulfone, polyether sulfone, polyether ether ketone, polyamide imide, polyether imide, a chlorotrifluoroethylene-ethylene copolymer, and the like.

The material of the metal portion is not limited to stainless steel, but a metal having a resistance to corrosion and a high mechanical strength, or its alloy may be used.

As has been described above, according to the present invention, since a resin is used to form only a surface of the retainer ring which is to come into contact with the polishing pad, a higher mechanical strength than that obtained when the entire retainer ring is made of only a resin can be obtained. As a result, even when the number of polishing processes increases, the retainer ring does not substantially deform, and occurrence of an abnormality in polishing amount on the outer peripheral portion of the substrate as the polishing target can be suppressed.

What is claimed is:

1. A polishing apparatus comprising:

a polishing pad adhered to a polishing table;

a substrate holder for holding a substrate as a polishing target, while urging a polishing target surface of the substrate against said polishing pad; and

a retainer ring formed on a holding surface of said substrate holder to correspond to a circumference of the substrate, said retainer ring having a resin portion formed on a surface thereof which is to come into contact with said polishing pad, and an annular holding portion for holding said resin portion and made of a material having a higher mechanical strength than said resin, wherein said retainer ring resin holding portion is encapsulated with said resin portion.

2. A polishing apparatus comprising:

a polishing pad adhered to a polishing table;

a substrate holder for holding a substrate as a polishing target, while urging a polishing target surface of the substrate against said polishing pad; and

a retainer ring formed on a holding surface of said substrate holder to correspond to a circumference of the substrate, said retainer ring having a stepped resin portion formed on a surface thereof, a smaller diameter upper portion of said stepped resin portion disposed to come into contact with said polishing pad, and an annular holding portion for holding said resin portion and made of steel.

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